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Abstract

IRRADIATION BEHAVIOUR OF STEEL AS A STRUCTURAL AND CLADDING MATERIAL

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Ferritic steel tensile specimens, irradiated at controlled temperatures in the range of 100 to 350°C in a series of reactor spectra, have been tested at room temperature and the effects on the lower yield stresses determined. The magnitudes of the radiation hardening are a function of the neutron dose, irradiation temperature, neutron spectrum and type of steel but are independent of the neutron dose rate. The increases in tensile lower yield stresses ($\Delta\sigma_y$) at 150°C can be given by $\Delta\sigma_y = A(\emptyset t)^{\frac{1}{2}}_{Ni}$ where $(\emptyset t)_{Ni}$ is the fission neutron dose and A is a constant. The hardening is a maximum after irradiation at 100°C.and decreases after irradiation at higher temperatures due to annihilation or redistribution of the point defects.

The effects/

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The effects of neutron spectrum have been analysed in terms of various models of radiation damage and the results used to predict the irradiation embrittlement of the CALDER HALL pressure vessel steel over the life-time of the reactor. After 5 years operation the predicted increase in ductile-brittle transition temperature is about 5°C irrespective of the model used; this is consistent with the results of tests on monitoring specimens exposed adjacent to the pressure vessel and removed after 5 years operation of the reactor. Comparison of the irradiation embrittlement in thick plate and small specimens shows that no significant specimen size effect exists.

The effects of neutron irradiation are to increase the proof and ultimate stresses and to reduce the ductility of austenitic steels in post-irradiation tensile tests at temperatures below about 500°C. These changes in properties can be correlated with the fission (or fast) neutron dose and result from the introduction of point defects into the lattice by fast neutron-atom collisions.

Further reductions in tensile ductility are obtained on testing the irradiated austenitic steels at temperatures above about 650°C. This high temperature loss in ductility is a function of the thermal neutron dose and the magnitude of the effect is independent of the irradiation temperature. The reduction in ductility is probably due to the formation of the precipitates which have been observed on the dislocations and at the grain boundaries in the irradiated specimens. Pre-treatment of austenitic steels, involving precipitating as much as possible of the carbon and nitrogen out of solution in the steel and refining the grain size, reduces the magnitudes of the high temperature loss in ductility in post-irradiation tensile and stress-rupture tests.

The reduction in ductility is not due to irradiation enhanced diffusion but to a thermal neutron induced transmutation effect; preliminary results suggest that the products of the $^{10}B(n,\alpha)^{7}Li$ reaction are either directly or indirectly responsible for the effects observed.